

EXHIBIT 2

BEST AVAILABLE COPY

FAX NOTE

Duncan - here are some words for you to pass through to your patent attorney. It is my hope that these ideas form the basis for a patent.

Please let me know how I can help get this patent written and assigned to ATML.

Bruce

Copy to MAT -
JEB -

1/9/95



Created using WinFax PRO 3.0 Delta Technology Inc.

To: Duncan Browb
From : Bruce Baretz
Pages: 14
For information Call: Bruce Baretz
At: 201-728-3102
Fax Number : 201-728-3102

From: Bruce Baratz To: Duncan Group

Date: 1/20/05 Time: 08:45:13

Page 2 of 16

ATMI Record of Invention #95-2 ATMI File No. 198

White Light Emitting Diodes Based on Fluorescent Impregnation

Invention Report

Prepared by: Bruce Baratz, Koen Solutions, Inc. on Jan 7, 1995

1. What Is It?

The invention relates to the utilization of a single source (typically monochromatic) light emitting diode die that activates (photoexcites) the ground state of soluble fluorophores encapsulated in a polymeric matrix (or otherwise placed in a non active region of a light emitting diode assembly) whereby these fluorophores, after photoexcitation, re-emit their absorbed energy at a wavelength and wavelengths bathochromic to the initial wavelength of emission coming from the active layer of the light emitting diode.

2. Why Is It Useful?

a. The invention allows for the use of a single light emitting diode die to emit light with "white" coloration without requiring the manufacturing of a complex set of diode dice or subassemblies, as white light emission is presently obtained by the simultaneous utilization of red, green and blue light emitting diode dies. In this invention, the white light emission can be obtained using a single light emitting diode die and a composition of a single or mixture of soluble fluorophores that emit a broad range of wavelengths thereby offering a white light. Further, these fluorophores can be selected in a manner that allows for different hues of white to be manufactured by a simple adjustment of the concentrations of the fluorescent compositions.

b. The invention also allows for the development of a single light emitting diode die, perhaps in the ultraviolet or in the blue, that can be used to prepare light emitting diode lamps of virtually any coloration or wavelength, including all shades and hues of white. Further, the invention allows for the preparation of broad band emitting light emitting diode lamps, as opposed to the current situation where monochromatic light is typically obtained.

c. The invention allows for the utilization of light of any color and provides for a shift of the light emission to a desired spectrum, without a loss of light intensity, provided fluorophores with fluorescent quantum yields of 1.0 are utilized. Allows for better color matching of LED lamps with incandescent lamps they are designed to replace, without requiring a substantial redesign of the p-n junction.

3. What Materials Show It?

*Read and
understood
Joullé
1-10-95*

From: Bruce Bahr: To: Deane Bahr

Date: 08/05 Time: 08:44:28

Page 3 of 14

Koen Solutions, Inc.

Patent & Prior Art Search: White Light Emitting Diodes based on Fluorescent Impregnation
01/08/95 Date: 01-07-95

In the present invention, fluorescent dyes developed for the polymer industry are believed to provide a suitable mixture of emission to generate white light. Further, light emitting diode dyes based on GaN and SiC active layers are thought to provide suitable activation wavelengths to cause the generation of white light.

4. Prior Art (Some relevant prior art. Full compendium is a database search submitted to ATMI on 12-20-94).

a. white LEDs -

I. TI White light-emitting organic electroluminescent devices using the poly(N-vinylcarbazole) emitter layer doped with three fluorescent dyes.
AU Kido, J. (Department of Materials Science and Engineering, Yamagata University, Yonezawa, Yamagata 992 (Japan)); Hoshino, K. (Department of Materials Science and Engineering, Yamagata University, Yonezawa, Yamagata 992 (Japan)); Okajima, K. (Department of Materials Science and Engineering, Yamagata University, Yonezawa, Yamagata 992 (Japan)); Nagai, K. (Department of Materials Science and Engineering, Yamagata University, Yonezawa, Yamagata 992 (Japan)).

SO Appl. Phys. Lett. (14 Feb 1994) v. 64(7) p. 815-817
Current Physics Microform No.: 9401G2156

ISSN 0003-6951; CODEN APPLAB

CY UNITED STATES

DT Journal

TC Experimental

LA English

AB White light-emitting electroluminescent devices were fabricated using poly(N-vinylcarbazole) (PVK) as a hole-transporting emitter layer and a double layer of 1,2,4-triazole derivative (TAZ) and tris(8-quinolinolato)aluminum(III) complex (Alq) as an electron transport layer. The PVK layer was doped with fluorescent dyes such as blue-emitting 1,1,4,4-tetraphenyl-1,3-butadiene, green-emitting coumarin 6, and orange-emitting DCM 1. A cell structure of glass substrate/indium-tin-oxide-doped PVK/TAZ/Alq/Mg:Ag was employed. White emission covering a wide range of the visible region and a high luminance of 3400 cd/m² were obtained at a drive voltage of 14 V. --

II. TI Visible electroluminescence from mu o-SiC/porous Si/Si p-n junctions.
AU Mimura, H.; Futagi, T.; Matsumoto, T.; Katsuno, M.; Ohta, Y.; Kikumura, K. (Electron. Res. Labs., Nippon Steel Corp., Kawasaki, Japan)

SO International Journal of Optoelectronics (March-April 1994) vol.6, no.2
p.211-15, 17 refs.

Price: OCCC 0952-5432/94/\$10.00

CODEN: IJOEEV ISSN: 0952-5432

DT Journal

TC Experimental

CY United Kingdom

LA English

DN A9419-7860F-007; 88410-4260D-010

AB We have fabricated two kinds of Si light emitting diodes (LEDs) consisting

From: Bruce Barab: To: Jordan Barab

Date: 1/08/95 Time: 08:45:47

Page 4 of 14

Kern Solutions, Inc.

Patent & Prior Art Search: White Light Emitting Diodes based on Fluorescent Impregnation.
01/08/95 Date: 01-07-95

of n-type microcrystalline silicon carbide (μ -c-SiC)/porous silicon (PS)/p-type crystalline silicon (c-Si) p-n junctions and demonstrated a visible light emission from them. We have observed three types of visible light emission: a very weak white light emission at a forward current of about 90 mA/mm² and a strong orange-red light emission at a forward current from 200 to 619 mA/mm² for the Si LED using a 3.5-4.5 Ω cm c-Si substrate, and a uniform red light emission at a forward current above 12 mA/cm² for the Si LED using a 0.2-0.4 Ω cm c-Si substrate.

AN 92:4211891 INSPEC DN B9208-4260D-010

TI Amorphous carbon based blue light electroluminescent device.

AU Yoshimi, M.; Shimizu, H.; Hattori, K.; Okamoto, H.; Hamakawa, Y. (Fac. of Eng. Sci., Osaka Univ., Japan)

SO Optoelectronics - Devices and Technologies (June 1992) vol.7, no.1, p.69-81, 20 refs.

CODEN: ODTEEG ISSN: 0912-5494

DT Journal

TC Practicat; Experimental

CY Japan

LA English

DN B9208-4260D-010

AB Blue light emission has been observed in hydrogenated amorphous carbon (a-C:H) based multilayered thin-film electroluminescence (EL) mode structure. The device is composed of a-C:H/a-SiC:H active layers sandwiched between hydrogenated amorphous silicon nitride (a-SiN:H) insulating layers, all of which are prepared by RF plasma chemical vapor deposition. A series of technical data on the device performance, including luminance, transferred charge density and emission spectrum are presented. Developed devices exhibit a broad band white light emission having a luminance up to 20 cd/m². However, purity of emission color is remarkably improved by insertion of a-SiC:H layer in the middle of the active a-C:H layer.

II. AN 92:4234151 INSPEC DN B9210-4260D-012

TI Amorphous thin film white-LED and its light-emitting mechanism.

AU Chen Zhiming; Sun Guosheng; Pu Hongbing (Shaanxi Inst. of Mech. Eng., Xi'an, China)

SO Conference Record of the 1991 International Display Research Conference (Cat. No.91CH3071-8)

New York, NY, USA: IEEE, 1991. p.123-5 of vi+257 pp. 4 refs.

Conference: San Diego, CA, USA, 15-17 Oct 1991

Sponsor(s): IEEE; SID; Advisory Group Electron Devices

Price: CCCC CH3071-8/91/0000-0123\$01.00

ISBN: 0-7803-0213-3

DT Conference Article

TC Practical

CY United States

LA English

DN B9210-4260D-012

AB Thin film light-emitting diodes (TFLEDs) made of amorphous semiconductor silicon carbide (a-SiC:H) have been developed by glow discharge deposition in an SiH₄-CH₄ mixture. White light emission is observable in the samples with a structure of either glass/ITO/a-SiC:H/AI or glass/ITO/p-n a-SiC:H/AI when a proper critical condition has been established. The light-emitting mechanism associated with these LEDs is suggested to be an

From: Bruce Baratz, The Quantum Source

Date: 10/06 Time: 06:47:00

Page 6 of 14

Kreon Solutions, Inc.

Patent & Prior Art Search: White Light Emitting Diodes based on Fluorescent Impregnation
01/08/95 Date: 01-07-95

radiative recombination of the electrons in the extended states of the conduction band and the holes in the localized states of the valence band.

IN AN 92(10):133581 COMPENDEX DN 9210131365

TI Amorphous thin film white-LED and its light-emitting mechanism.

AU Chen, Zhiming; Sun, Guosheng; Pu, Hongbing

MT Conference Record of the 1991 International Display Research Conference.

MO IEEE Electron Devices Soc; Society for Information Display, Advisory Group on Electron Devices

ML San Diego, CA, USA

MD 15 Oct 1991-17 Oct 1991

SO Conference Record of the 1991 International Display Research Conference

Conf Record 91 Int Display Res Conf, Publ by IEEE, IEEE Service Center,

Piscataway, NJ, USA (IEEE cat n 91CH3071-5), p 122-125

ISBN: 0-7803-0213-3

PY 1991

MN 18908

DT Conference Article

TC Experimental; Theoretical

LA English

AN 92(10):133581 COMPENDEX DN 9210131365

AB Thin film light-emitting diodes (TFLEDs) made of amorphous semiconductor silicon carbide (a-SiC:H) have been developed by glow discharge deposition in an SiH_4 plus CH_4 mixture. White light emission is observable in the samples with a structure of either glass/ITO/a-SiC:H/Al or glass/ITO/p-n a-SiC:H/Al when a proper optical condition has been established. The light-emitting mechanism associated with these LEDs is suggested to be an radiative recombination of the electrons in the extended states of the conduction band and the holes in the localized states of the valence band. 4 Refs.

IN AN 91(17):28800 PHYS

TI Blue-emitting electroluminescent phosphors: review and status.

AU Lersch, S. (DevTech Inc., Princeton, NJ (USA)); Morton, D.C. (U.S. Army Electronic Devices and Technology Lab., Fort Monmouth, NJ (USA))

NR Ph-170

SO 5. International Workshop on Electroluminescence.

Leskela, M. (Turku Univ. (Finland); Helsinki Univ. of Technology

(Finland)); Nytaanen, E. (Helsinki Univ. of Technology (Finland)) (eds.)

Finnish Academy of Technology, Helsinki (Finland)

1990 p. 137-143 of 316 p.

Acta Polytech. Scand., Appl. Phys. Ser. no. 170

Conference: 5. International Workshop on Electroluminescence (EL-5).

Helsinki (Finland), 11-13 Jun 1990

ISSN 0355-2721; CODEN APSSD; ISBN 951-658-317-6

CY FINLAND

DT Miscellaneous; Conference

TC Experimental

LA English

AB While TFEL has made enormous strides in the last several years, the weak point in achieving a high luminance display is the continued lack of an efficient blue-emitting electroluminescent phosphor. This paper reviews the

From: Bruce Baratz Tel: 0900000000

Date: 1995 Time: 08:02:20

Page 6 of 14

Kean Solutions, Inc.

Patent & Prior Art Search: White Light Emitting Diodes based on Fluorescent Impregnation

01/08/95 Date: 01-07-95

field of blue-emitting EL phosphors, and presents research results on one of the possible candidates for TFEL displays.

VI. AN 90:3633232 INSPEC DN B90040508

TI Toward a visible light display by amorphous SiC:H alloy system.

AU Hamakawa, Y.; Kruengam, D.; Toyama, T.; Yoshimi, M.; Paschoe, S.; Okamoto, H. (Fac. of Eng. Sci., Osaka Univ., Japan)

SO Optoelectronics - Devices and Technologies (Dec. 1989) vol.4, no.2, p.281-94, 25 refs.

CODEN: ODTEEG ISSN: 0912-5434

DT Journal

TC Practical; Experimental

CY Japan

LA English

DN B90040508

AB A series of experimental trials to realize flat panel display devices using plasma CVD-produced a-Si_{1-x}C_xH alloy has been reported. Fabrication technology and basic properties of the active material a-Si_{1-x}C_xH alloy are briefly introduced. Then the technical data on both injection type and intrinsic type EL devices are presented. The injection type EL device (LED) has a basic structure of p (a-SiC_{1.9}H_{0.1}) / (a-SiC_{1.9}H_{0.1}) / (a-SiC_{1.9}H_{0.1}), and the emission color can be controlled from red to green by adjusting the carbon content x in the a-Si_{1-x}C_xH luminescent i-layer. The luminance of 20 cd/m² was obtained from the yellow LED with a forward injection current density of 600 mA/cm². The intrinsic EL device (TFEL) shows a luminance of 30 cd/m² for the blue color emission and 40 cd/m² for white light so far. The developed devices have some significant advantages over the conventional crystal LEDs: wide area, ease of fabricating integrated type multi-color or tunable color LEDs, and low cost. Utilizing these characteristics, new types of optoelectronic functional elements are proposed and discussed.

VI. AN 88(16):77843 PHYS

TI White light emitting thin-film electroluminescent devices with SrS:Ca, Cl/ZnS:Mn double phosphor layers.

AU Tanaka, S.; Mitani, Y.; Deguchi, H.; Kobayashi, H. (Dept. of Electronics, Tottori Univ. (Japan))

SO Jpn. J. Appl. Phys., Pt. 2. (Mar 1988) v. 25(3) p. L225-L227

ISSN 0021-4922; CODEN JAPLDD

CY JAPAN

DT Journal

TC Experimental

LA English

AB White light emitting thin-film electroluminescent devices have been fabricated. The devices consist of double phosphor layers of a greenish-blue light emitting SrS:Ca, Cl and a yellowish-orange light emitting ZnS:Mn. A brightness level of 1100 cd/m² at 5 KHz drive has been obtained. (orig.)

VI. AN 92-368485 [44] WPINDE

DNN N92-279300

TI Tunnel junction multiple wavelength light-emitting diode for display system - has p-n junctions with different band gaps which may be collectively energized.

From: Bruce Baratz To: Dumas Brash

Date: 1/09/95 Time: 08:48:48

Page 7 of 14

Keen Solutions, Inc.

Patent & Prior Art Search: White Light Emitting Diodes based on Fluorescent Impregnation
01/09/95 Date: 01-07-95

DC U12 U13

IN KURTZ, S R; OLSON, J M

PA (MIDE) MIDWEST RES INST

CYC 34

PI WO 9217909 A1 921015 (9244)* EN 11 pp

RW: AT BE CH DE DK ES FR GB GR IT LU MC NL OA SE

W: AT AU BB BG BR CA CH DE DK ES FI GB HU JP KP KR LK LU MG MW NL NO

PL RO RU SD SE US

US 5166761 A 921124 (9250) 8 pp

AU 9217577 A 921102 (9305)

ADT WO 9217909 A1 WO 92-US2281 920323; US 5166761 A US 91-678230 910401; AU

9217577 A AU 92-47577 920323, WO 92-US2281 920323

FDT AU 9217577 A Based on WO 9217909

PRAI US 91-678230 910401

AN 92-368485 [44] WPINDEX

AB WO 9217909 A UPAB: 931006

A multiple wavelength light-emitting diode has a monolithic cascade cell structure comprising at least two p-n junctions with GaInP2/GaAs as top/bottom cells. This gives each junction different band gaps.

An electrical connection is then structured in place so that all of the p-n junctions are simultaneously energised to emit corresponding wavelengths or colours. A transparent tunnel p-n junction of GaAs n+/GaAs p+ interconnects the diodes.

ADVANTAGE - Provides three primary colours or emits them simultaneously to produce white light in a display.

3/5

ABEQ US 5166761 A UPAB: 931006

The multiple wavelength light emitting diode comprises a multiple layered, single structure of several LED's of varying band gaps, and is made by depositing thin films of alternating p-doped and n-doped materials, wherein the lowest band gap material is deposited first and the highest band gap material is deposited last. Electrical connections are then structured in place so that all of the n-p junctions can be collectively energised to emit simultaneously the corresponding wavelengths or colours. The device may be utilised to provide the three primary colours or emit them simultaneously to produce white light.

USE - LED visual display of more than one colour.

2/5

x. AN 79-72319B [40] WPINDEX

TI White light emitting diode or triode - having semiconductor and semiconductor oxide layers and metal contact pad so that light appears as halo around pad.

DC L03 U12 U14 X26 X28

IN BAYRAKTARO, B M; HARTNAGEL, H L

PA (BAYR-D) BAYRAKTAROGU B

CYC 1

PI GB 2017409 A 791003 (7940)*

PRAI GB 78-11422 780322; GB 79-13930 790420

AN 79-72319B [40] WPINDEX

AB GB 2017409 A UPAB: 930901

An LED emitting white light when reverse biased comprises (a) a semiconductor, (b) a layer of semiconductor oxide on top semiconductor and

From: Bruce Baratz To: Danica Brown

Date: 1/28/95 Time: 06:51:05

Page 8 of 14

Kean Solutions, Inc.

Patent & Prior Art Search: White Light Emitting Diodes based on Fluorescent Impregnation
01/08/95 Date: 01-07-95

(c) a metal pad on the oxide. A double oxide LED comprises an LED as above having a layer of Al_2O_3 between the metal pad and an oxide of the semiconductor. The Al_2O_3 oxide of the semiconductor are both 20-70 angstroms thick.

A light emitting triode comprises an LED as above, with a second metal pad spaced from the first metal pad and contacting the semiconductor oxide.

Preferably, the semiconductor is Si, having ample superficial trap density or III-V or II-VI semiconductors, esp. n-type GaAs.

The light appears as a halo round the pad and is continuous over the visible spectrum and into the infrared. For luminescence over an area a grid electrode or very thin electrode may be used. Typical temp. range of operation is 77-323 K for GaAs device, with higher efficiency at lower temp.

b. Phosphors and LEDs - active layer

1. AN 92:4211991 INSPEC DN B9209-42600-010

T1 Amorphous carbon based blue light electroluminescent device.

AJ Yoshimi, M.; Shimizu, H.; Hattori, K.; Okamoto, H.; Hamakawa, Y. (Fac. of Eng. Sci., Osaka Univ., Japan)

SO Optoelectronics - Devices and Technologies (June 1992) vol.7, no.1, p.69-81, 20 refs.

CODEN: OOTEEG ISSN: 0912-5434

DT Journal

TC Practical; Experimental

CY Japan

LA English

DN B9209-42600-010

AB Blue light emission has been observed in hydrogenated amorphous carbon (a-C:H) based multilayered thin-film electroluminescence (EL) mode structure. The device is composed of a-C:H/a-SiC:H active layers sandwiched between hydrogenated amorphous silicon nitride (a-SiN:H) insulating layers, all of which are prepared by RF plasma chemical vapor deposition. A series of technical data on the device performance, including luminance, transferred charge density and emission spectrum are presented. Developed devices exhibit a broad band white light emission having a luminance up to 20 cd/m². However, purity of emission color is remarkably improved by insertion of a-SiC:H layer in the middle of the active a-C:H layer.

2. AN 92(10):62806 PHYS

T1 Several blue-emitting thin-film electroluminescent devices.

AU Miura, Noboru; Ishikawa, Tetsuo; Sasaki, Takashi; Oka, Toshiyuki; Ohata, Hiroshi; Matsumoto, Hironaga; Nakano, Ryotaro (Dept. of Electronics and Communication, Meiji Univ., Kawasaki (Japan))

SO Jpn. J. Appl. Phys., Pt. 2, (15 Jan 1992) v. 31(1A/B) p. 48-48

ISSN 0021-4922; CODEN JAPLDD

CY JAPAN

DT Journal

TC Experimental

LA English

AB Blue-emitting thin-film electroluminescent (EL) devices were studied. As the blue-emitting phosphor, thin-films in which the Tm^{3+} ion was doped into several hosts (ZnS , Y_2O_3 , CdF_2 , ZnF_2 and YF_3) and $CaF_2:Eu$ were

From: Bruce Gerzic To: Dusan Brand

Date: 10/06 Time: 08:22:27

Page 9 of 14

Keen Solutions, Inc.

Patent & Prior Art Search: White Light Emitting Diodes based on Fluorescent Impregnation
01/08/95 Date: 01-07-95

Investigated. Blue EL emission of Tm^{3+} ions arising from the $1G_4 \rightarrow 3H_4$ or $1G_4 \rightarrow 3H_6$ transition was observed in each Tm -doped device. The most dominant lines in these emissions varied with the kind of host materials. The $CaF_2:Eu$ thin-film also showed blue electroluminescence due to a partly-allowed $4f(7F)5d \rightarrow 4f(8S)$ transition of the Eu^{2+} ion. (orig.)

c. Upconversion - this process converts monochromatic (narrow band) light into second or third harmonics of the initial light wavelength and, hence, the efficiency of the light emission is a function of the intensity. Further, the light emission remains monochromatic and can not be used to generate white light. Further, the intensities of current light emitting diodes are not thought to be sufficient to allow for up conversion to practically take place (although the light emission from diode lasers are probably sufficient).

I AN 87:2089562 INSPEC ON A87110582; B87083351

TI Various performances of fiber-optical temperature sensor utilizing infrared-to-visible conversion phosphor.

AU Hirano, M.; Watanabe, M.; Yasuda, H. (Ron Tetsu Electron. Co., Kyoto, Japan)

SO Denki Kagaku (Feb. 1987) vol.55, no.2, p.158-64, 6 refs.

CODEN: DNKKA2 ISSN: 0368-9287

DT Journal

TC Experimental

CY Japan

LA Japanese

DN A87110582; B87083351

AB A fiber-optical temperature sensor utilizing temperature-sensitive emission of an infrared-to-visible conversion phosphor $YF_3:Yb, Er$ has been developed. This sensor was successfully applied to temperature measurements in the 3 kW-microwave field. The accuracy of ± 0.5 degrees C over the range of -20 degrees C to +200 degrees C was obtained. It was found that the margin of instrument error included the difference of measured temperature and previously calibrated temperature. The instrument error was compensated by calculating the correction. The precise technique to meet temperature-sensitivity of the probe with its calibration curve has been developed. The thermal drifting in the temperature indication was decreased by the stabilization of an infrared excitation with use of an LED feedback control. This is explained by the fact the efficiency of the phosphor excitation is maintained to be constant by the competitive actions of thermally induced fluctuations in intensity and wavelength of an LED emission. The competitive actions for the $YF_3:Yb, Er$ phosphor are effective for the excitation wavelength of 940 to 950 nm.

I AN 90:177498 HCA

TI Pulse operating up-converting phosphor LED

AU Zdanowski, Marek

CS Inst. Electron Technol., Sci. Prod. Cent. Semicond., Warsaw, Pol.

SO Electron Technol. (1976), 11(3), 49-61

CODEN: ETNTAT; ISSN: 0070-8818

DT Journal

LA English

From: Simon Barakat To: Dupont@steeb

Date: 9/29/95 Time: 04:22:49

Page 10 of 14

Koen Solutions, Inc.

Patent & Prior Art Search: White Light Emitting Diodes based on Fluorescent Impregnation
01/08/95 Date: 01-07-95

AB On the basis of a kinetic model of Yb^{3+} - Er^{3+} system, an anal. was made of the performance of $\text{YF}_3\text{:Yb}^{3+}$, Er^{3+} IR-to-visible conversion source with cooperating light emitting diode driven with rectangular current pulses.

III. AN 90:177497 HCA

TI Infrared-to-blue up-converting phosphor

AU Wojciechowski, Jerzy; Pawelska, Irena

CS Inst. Electron Technol., Sci. Prod. Cent. Semicond., Warsaw, Pol.

SO Electron Technol. (1978), 11(3), 31-47

CODEN: ETNTAT; ISSN: 0070-9816

DT Journal

LA English

AB The emission spectrum of the $\text{YF}_3\text{:Yb}^{3+}$, Tm^{3+} up-converting phosphor was studied, which resulted in the introduction of schematic manners for both energy transfer and radiative deexcitation in the Yb^{3+} - Tm^{3+} system. Principal performance characteristics were ded. for such type of up-converting phosphor-light-emitting diode system acting as a blue emission source.

4. Invention

a. Development of a white light emitting diode using a blue or UV light emitting diode die and a fluorophore or combination of fluorophores encapsulated within the plastic encapsulating dome above the active layer of said die. The fluorophores are chosen in such a manner that they absorb the monochromatic light emission from the UV or blue light emitting die and spontaneously emit the absorbed light as fluorescent or phosphorescent light emissions over a broader spectrum and bathochromic to the original wavelength of emission. With the spontaneous re-emission of light over a broad range of wavelengths, the appearance of said light can be adjusted to appear white of any shade or hue.

b. Development of a light emitting diode using a blue or UV light emitting diode die and a fluorophore or combination of fluorophores where the spontaneously emitted fluorescence or phosphorescence is a broad emission and is of any color or hue other than the color of the initial emission from the light emitting diode die.

c. Development of a light emitting diode using a blue or UV light emitting diode die and a segregated assembly of fluorescent or phosphorescent dies such that different portions of the plastic encapsulating dome emits color of different wavelengths and hence provides a multiple color lamp products.

d. Development of a light emitting diode lamp using a blue or UV light emitting diode die whereby the incidence of illumination is dramatically increased by virtue of the spontaneous fluorescence

Jan 10 1995

From: Bruce Baratz To: Duncan Smith

Date: 1/28/05 Time: 08:58:10

Page 11 of 14

Keen Solutions, Inc.

Patent & Prior Art Search: White Light Emitting Diodes based on Fluorescent Impregnation
01/08/95 Date: 01-07-05

and phosphorescence, from the selected dyes, is emanating from a lambertian surface, as opposed to a point source from a single point p-n junction.

e. Development of a light emitting diode lamp using a blue or UV light emitting diode die whereby the color of the spontaneous emission can be varied as a function of ambient temperature (and, hence, the applied voltage) where the fluorescent or phosphorescent dyes emit different wavelengths of emission as a function of temperature.

f. Development of a light emitting diode lamp with a long memory of re-emission of light in such a manner that the re-emitted light continues to be observed for several hours after the applied voltage is removed by the incorporation of suitable phosphorescent materials into the encapsulating matrix.

g. Development of a light emitting diode where an electrical pulse is delivered (to minimize power drain from the battery source) but where a continuous period of illumination is realized by adjustment of the luminescence lifetimes of suitable phosphor;

h. Development of a light emitting diode where the total illuminance is increased by virtue of shifting the illumination wavelengths of any short wavelength emitting p-n junction towards the photopic maximum.

i. Development of a light emitting diode where a photochromic phosphor is used such that the illumination wavelength during day or night usage is different by virtue of using incident sunlight to adjust the chromaticity of the incorporated dye.

5. Distinction from Prior Art

a. Phosphors are not incorporated into active layer thereby not impacting the inherent efficiencies of the p-n junction;

b. White light emission can be obtained using one addressable die;

c. Different shades and hues can be obtained from the same underlying diode die by modifying the encapsulating material which occurs later in the manufacturing process;

d. Colors and shades are not limited to monochromatic emissions, although they could be designed as such;

e. Efficiencies of light emission are not intensity dependent as in up-conversion.

Handwritten signature
1-20-05

Print: Status Report To: Charles Smith

Title: WHITE LIGHT EMITTING DIODES

Page: 14 of 17

Koen Solutions, Inc.

Patent & Prior Art Search: White Light Emitting Diodes based on Fluorescent Impregnation

01/08/95 Date: 01-07-95

- f. Selection of fluorophors and phosphors are not limited to those that are compatible with active layer;
- g. Incidence of illumination can be improved and broadened over a greater range than available from any other method presently used in LED fabrication;
- h. Potential for lasing to take place within dome?
- i. opportunity to develop lambertian surface emission from an otherwise point source.

6. Details of Method

- a. Blue or UV light-emitting diode die, made from a GaN or SiC or any other semiconductor known to produce UV or blue light is cut;
- b. Die is potted into an encapsulating dome containing mixture or specially designed fluorophor or phosphor;
- c. Concentration and path length of dome is selected to maximize the emission yields and color.

7. Claims

Patent Introduction:

Considerable efforts have been advanced in the area of developing full-color and white light emitting diode systems to replace existing illumination devices based on incandescent and fluorescent (mercury vapor) bulbs. The practical advantages of illumination devices based on light emitting diodes are many and include higher reliability, lower power consumption, shock resistance, longer illumination duration, discrete wavelengths of illumination and focused illumination output. It is important to note, however, that certain of these practical advantages can be considered design disadvantages in the context of special systems. For example, whereas the focused light output from a typical light emitting diode allows for alignment of the light intensity without requiring a sophisticated and expensive lens system, in those applications where the illumination needs to be observed across a wide face, the requirement to defocus the other illumination cone is clearly a disadvantage.

One application where light emitting diodes are beginning to become an accepted replacement for incandescent bulbs is in the area of electronic message signs used to supply advertising media as well as the current time and temperature. Many of these signs are resident in the outdoors and need to be bright

Jeffrey
1-10-95

Green Seal, Inc.

Patent & Prior Art Summary: White Light Emitting Diodes Based on Fluorescent Incorporation
01/08/95 Date: 01-07-05

enough to be observed in the daylight and from a suitable distance. In most cases, emitting outdoor signs have relied upon incandescent lamps which, because of their broad spectral emission spectrum, are observed to fluctuate in a white color. For these outdoor applications, the light emitting diodes provide a tremendous advantage in that their burn time is in excess of ten years, whereas incandescent lamps regularly burn out and, thus, leave an empty panel in the message. In real world applications, the burn out of the panel makes the message unreadable or, at best, provides a significant maintenance expense to the maintenance of the outdoor signs.

Current usage of light emitting diodes in outdoor and other signage have been restricted to either red or amber emission colors. Although other monochromatic colors are available, the intensity of the light emitting diode tends to be in excess of 1000 mcd and, hence, have been limited to hard to visualize colors. Further, the availability of signage in monochromatic colors of red and amber have limited their acceptance as replacements for white incandescent lamps, despite the maintenance and low power consumption advantages of the light emitting diode, in general.

White light can, in theory be produced in outdoor light emitting diode assemblies, but presently, the broad band emission necessary to produce white light requires the use of many light emitting diode lamps incorporated into conventional LED modules. In many cases, the modules contain at least 8 and up to 22 components where blue, green and red light emitting diode lamps are electrically powered and modulated in such a manner as to provide the appearance of monochromatic light blended in such a manner as to provide a white light source. The high cost and low efficiency of these modules make them relatively unsuitable as replacements for single incandescent white lamps and hence, the availability of white light emitting diode lamps, especially based on single semiconductor diode, are highly wanted.

It is the claim of this invention that single semiconductor diode can be incorporated into a single light emitting diode part, that has been incorporated with fluorescent agents and impurities phosphor and phosphor and into which the blue or ultraviolet radiation of the part and provides a substantial portion of the energy. One major unexpected advantage of using this process to construct the monochromatic light assembly combined by a light emitting diode is the development of a single diode that yields a broad band emission, in fact, comparable to the initial wavelength of emission, and is emitted with the appearance of white light. Further, this invention will allow for the direct replacement of single incandescent white lamps with single, single light emitting diode lamps that directly provide a white light emission and which incorporated all of the other advantages of light emitting diodes.

James H. H. H.
1-10-05

Keen Solutions, Inc.

Patent & Prior Art Search: White Light Emitting Diodes based on Fluorescent Impregnation

01/08/95 Date: 01-07-85

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☒ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.